Demonstration Report on

Radionuclide Decontamination of Metal Using TechXtract[tm] Technology For Taiwan Power

Introduction

On March 11 and 12, 1998, Active Environmental Technologies conducted a pilot plant demonstration using the TechXtract[tm] technology to remove hard fixed radionuclides from a variety of metal substrates. The demonstration was done in conjunction with Sunrise Environmental Services of Taipei, Taiwan, at the First Nuclear Power station of Taiwan Power. The TechXtract[tm] process is a commercial technology that has already had success at a number of commercial and government sites removing radionuclides, metals, pesticides, chlorinated organics, and PCB's from concrete, metals, and other substrates.

TechXtract[tm] is a patented chemical decontamination technology that has applications including the removal of smearable and hard fixed radionuclides from a range of substrates. In order to demonstrate the technology's efficacy, a demonstration was conducted at Taiwan Power's First Nuclear Power Station located in Chin-shan, Taiwan. The demonstration's objective was to show that TechXtract could be used to remove fixed contamination from metals in inventory at the station. A secondary demonstration objective was to devise a treatment scheme that could be used by Taiwan power to release contaminated materials from its inventory.

Process Description

TechXtract[tm] utilizes the application of sequential chemistry, embodied in three solutions, to remove contaminants that have migrated into the microscopic pores of a substrate and become chemically bonded to that substrate. For radionuclides, this type of contamination is referred to as being "hard fixed". The TechXtract[tm] solutions used for this demonstration were formula designations Rad XT (0100), Rad Clean (0200), and Rad Pro (0300). All three formulas are aqueous and produce a non-hazardous secondary waste.

Once contaminants have bonded electrostaticly, they are not removable by typical surface decontamination techniques, such as acid wash, fluorocarbon solvent wash, carbon dioxide blasting, and chelant washing. The TechXtract[tm] chemistry is wet enough to penetrate the interstitial matrices of the substrate. It then breaks the electrostatic bonds, and micro-emulsifies the contaminants so that they can be removed from the substrate. Treatment schemes are individually designed to be effective on specific contaminant / substrate combination of concern in a given project.

For this demonstration to be successful, decontaminated items would need to meet free release levels of 1.66 Bq/100cm2 for smearable and 300 Bq/Kg for fixed contamination.

Below Regulatory Concern (BRC) contamination is 100 dpm / Kg for the Republic of China on Taiwan.

Demonstration Procedure

For the Taiwan Power demonstration, a treatment scheme was developed to remove fixed ^{137}Cs and ^{60}Co from metal substrates, excluding lead. (A separate treatment scheme is employed for lead decontamination.) Eleven different contaminated items were surveyed and supplied by Taiwan Power to be decontaminated. Due to time limitations, five items were chosen for the demonstration. Two of the items, a piece of steel pipe and a brass pump impeller, were parts from a dismantled wet-well sump pump, with hard fixed contamination at levels of 5,000,000 and 750,000 Bq / Kg respectively. The station considered decontamination of these last two items to be impossible, due to the high level of hard fixed radionuclides, the pressure of deposition, and the porous nature of the metal substrates.

The treatment cycle design for the contaminant / substrate combinations presented consisted of a procedure that used a protocol including:

1. Soak in formula 0300,
2. Sonication in a bath of 0300 (with reagent chemistry) for 15 minutes at 43°C,
3. Spray on 0200, scrub with a wire brush and dwell for 40 minutes,
4. Rinse with de-ionized water and vacuum off the solution,
5. Spray on 0100, scrub with a wire brush, and dwell for 60 minutes,
6. Rinse with de-ionized water and vacuum off the solution.

Scrubbing and sonication are used to impart kinetic energy to the contaminated surface that removes capillary blockage and allows TechXtract^{tm} chemical to penetrate.

Demonstration Equipment Limitations

Production scale TechXtract^{tm} decontamination schemes use sonication to provide a majority of the kinetic energy requirement. The high cost of sonication units restricted the number and size of the demonstration scale equipment. As a result, the larger parts, which included the brass impeller, the machine plate, hook, and funnel, could not be completely immersed in the sonication bath. In addition, sonication was used for the 0300 solution alone, and not for all three solutions, as would be typical. The importance of complete immersion in sonicators became evident after the initial wipe samples showed hot spots on items that had geometries that were difficult to reach with manual scrubbing.

While the volume of secondary waste was not a demonstration parameter, it was noted that approximately 4 gallons of liquid waste was generated. The volume of secondary waste was increased due to problems with temperature control on the sonicator that was used. Higher temperatures caused the solution to boil, which volatilized the solution's wetting agents, requiring premature discharge of the bath water. Full-scale metal

decontamination projects with TechXtract[tm] will produce a small secondary waste volume. A ratio of 1 volume of waste per 100 volumes of contaminated metal is typical.

Results

The demonstration was 100% successful in achieving its objective of decontaminating all of the items to free release. Further, all of the items with full decontamination cycles were reduced to activity levels of Below Regulatory Concern (<100 dpm). The results of the demonstration are summarized in Table 1.0 below. The results from the sump items are particularly significant due to the nature of the service and level of original fixed contamination. The sump pipe was found to be free release on its first post decon survey, so it is possible that the number of cycles required for decon was lower than what was employed. The demonstration also clearly demonstrated the desirability of using sonicators in the treatment equipment scheme, particularly where tough geometries are encountered.

TechXtract[tm] Decontamination Results. Table 1.0

Item / Material	Initial Activity		Final Activity		TechXtract[tm] Cycles
	Smear ($Bq/100cm^2$)	Fixed (Bq/Kg)	Smear ($Bq/100cm^2$)	Fixed (Bq/Kg)	
Hook / Forged Iron	18.98	< 1739	0.91	0	2
Funnel / Stainless Steel	10.63	<222	$\leq$1.66	222*	1
Machine Plate / Cast Iron	36.27	<2405	0.41	0	2
Sump Pipe / Steel	2500	5×10^6	0.55	0	3
Sump Pump Impeller / Cast Brass	25	7.5×10^3	0.62	0	5

*Reduced treatment cycle

Performance Impact of Geometry and Materials

Decontamination speed is greatly affected by the type of metal substrate and its geometry. Hard, relatively non-porous metals such as stainless steel will decon faster than soft porous metals such as brass. Geometries that include sharp, irregular, or hard to reach surfaces are more difficult to decon than flat or regular surfaces. This was born out during the demonstration.

The stainless steel funnel was decontaminated with an accelerated protocol in which the 0200 and 0100 dwell times were shortened to 2.5 minutes each. The forged steel and cast iron items with light contamination required two full cycles, and the heavily contaminated cast iron sump pipe still only required three full cycles. The brass pump

impeller required five full cycles, even though it had approximately one sixth the sump pipe's contamination level. It was also observed during the demonstration, that area on the items that were difficult to reach with our scrub brushes, like threaded holes, shaft bore holes, and the base of ridges, held contamination longer. As discussed above, it is felt that the availability of full sonication would have greatly decreased the time required for imparting kinetic energy to the difficult to reach surfaces. For example, the flat side of the brass impeller was decontaminated after its third cycle, while the drive shaft key-hole required two additional cycles before coming clean.

Geometric problems are less evident when sonication can be used to impart kinetic energy for all three chemical applications.

Secondary Waste Production and Treatment

One of the advantages of decontamination using TechXtract[tm] is the potential for waste volume reduction. Commercial plant decontamination projects typically achieve volume reduction ratios of 100 to 1 (metal to liquid waste) for metal substrates. Cementing, incineration, or co-precipitation has been used to further treat the liquid volume generated by the process for either fixation or further volume reduction. Co-precipitation or incineration is used when waste volume minimization is critical.

Co-precipitation provides a low capital cost alternative to incineration for further volume reduction, particularly for those clients that have wastewater treatment systems installed. This chemical treatment further reduces waste disposal to 6% of the original total process waste. By precipitating out the organic and metal constituents that are present in the process wastewater, 94% of the original volume can be put through ion exchange. The metals sludge and organic constituents are cemented for fixation.

Co-precipitation requires the following protocol:

1. pH is lowered to 0.5 with H_2SO_4,
2. Heat to 65°C,
3. Wait for phase separation,
4. Vacuum off the hydrocarbon layer
5. Decant aqueous phase and vacuum off sludge, adjust sludge pH to 9.5
6. Add 1% Fe_2SO_4 to aqueous layer to precipitate radionuclides (or pass through ion exchange)
7. Filter through 20 micron filter
8. Add 1% Fe_2SO_4 to co-precipitate
9. Filter through 20 micron filter

(Solubility of Cs requires an ion exchange resin for removal. Recommend IE911 or equivalent)

10. Neutralize aqueous phase to effluent.

Capital is required for chemical treatment day tanks, ion exchange column, and 20-micron filters.

Conclusion

The TechXtract[tm] process is 100% effective in removing fixed and smearable radionuclide contamination from metal substrates. The decontamination process is enhanced by the use of sonication to impart kinetic energy, particularly where sharp geometry is present.

We wish to express our sincere appreciation to Taiwan Power for their assistance and professionalism. In particular we wish to thank Mr. C.H.Lee, Decontamination Section Chief, Mr. Cho, Section Manager, and Mr. Wong, Decontamination Supervisor.

For more information on TechXtract[tm] applications for radionuclide contamination, call Scott Fay at 609-702-1500.